

ANNEX DD EARTHQUAKE PREPAREDNESS

I. SITUATION AND ASSUMPTIONS

A. Situation

1. An earthquake is a shaking or trembling of the earth's crust, caused by the breaking and shifting of rock beneath the surface or underground volcanic forces. While scientists are able to measure the amount of energy that is building beneath the earth's surface, they are not able to predict exactly when an earthquake will occur. Therefore, earthquakes are unpredictable and can strike without warning. They may range in intensity from slight tremors to great shocks and may last from a few seconds to as long as five minutes. Earthquakes can either occur by themselves or in a series over a period of several days, or even months. However, they are almost always accompanied by aftershocks, which can be equally as damaging as the quakes that they follow.
2. The actual movement of the ground in an earthquake is seldom the direct cause of casualties. Most casualties are from falling objects and debris as a result of shocks that shake, damage, or demolish buildings and other structures. This disruption of communications, power, gas, sewer and water systems can be expected. Earthquakes may also trigger landslides that can cause extensive damage.
3. Earthquakes can be experienced in any part of the Commonwealth with the majority of Kentucky's population at risk from earthquakes. The Commonwealth is vulnerable to a significant threat of damage from earthquakes from both identified and unidentified faults. This threat includes deaths and injuries to residents, as well as widespread property damage.
 - a. No part of Kentucky is free from this threat. Thousands of earthquakes have occurred in and around Kentucky from the New Madrid area in the west to Greenup County in the northeast and Bell County in the Southeast.
 - b. Every county has at least one fault running beneath it. These faults are overwhelmingly inactive and have been for thousands of years.
 - c. Some fault zones are considered active by the Kentucky Geologic Survey.
 - 1) New Madrid Fault Zone. The fault zone extends from Northeastern Arkansas, Northwestern Tennessee, Southwestern tip of Kentucky, to Southeastern Missouri. It is the most active fault in the Central and Eastern United States.

- 2) Wabash Valley Fault Zone. This zone is located in Southeastern Illinois, Southwestern Indiana, small part of Northwestern Kentucky. Five slightly damaging earthquakes, 5.0 – 5.8 and many smaller seismic events have occurred in the Wabash Valley Zone in Illinois and Indiana during the 100 years of historic record with several causing damage in Kentucky.
 - 3) Eastern Tennessee Fault Zones. In August 1997, the East Tennessee Seismic Zone produced a 3.8 quake in Tazwell, Tennessee, 15 miles south of Middlesboro in Bell County, Kentucky. A number of small earthquakes have also occurred along the course of the Pine Mountain in the Appalachian Area.
 - 4) A 5.2 earthquake occurred in 1980 near Sharpsburg in Bath County some 30 miles northeast of Lexington. This earthquake is believed to have originated along a buried ancient fault zone from an unmapped area of geologic stress and was, therefore, a geologic surprise. This quake caused \$3 million in damages, mostly in Maysville, Kentucky on the Ohio River, not Sharpsburg at the epicenter.
 - 5) Beginning at the eastern edge of the Blue Grass Region, the Kentucky River Fault System runs East-Northeast toward the Morehead/ Ashland areas and into West Virginia. This fault system runs beneath the Clays Ferry Bridge at the 99-mile marker on I-75 at the Madison-Fayette County line, and is part of a larger fault system. The southern band of the Kentucky River Fault System is the Paint Creek Fault, which runs through Hazard and further south.
- d. There is thus an urgent need to increase public awareness of all Kentuckians and for planners to prepare for the contingency of such an event in all areas of the state in order to mitigate the inherent dangers.
4. The infrastructure of this part of the country has not experienced a major earthquake since 1812.
- a. Effects of an earthquake would include:
- 1) Collapsed Buildings
 - 2) Ruptured natural gas and petroleum pipelines.
 - 3) Ruptured water and sewer lines.
 - 4) Downed electrical lines.
 - 5) Release of hazardous materials.

- 6) Fires resulting from broken gas lines or from other ignition sources.
 - 7) Collapsed bridges and overpasses (affecting transportation and the economy of the entire country).
 - 8) Downed telecommunications lines.
 - 9) Damaged or destroyed critical facilities.
- b. The greatest hazard potential is in highly populated areas, although the epicenter may be in a more sparsely populated area.
 - 1) Highly populated areas tend to have a greater number of old buildings, especially unreinforced masonry buildings that are more vulnerable to ground shaking.
 - 2) Buildings constructed between the 1920's and the 1960's are generally more susceptible to seismic movement.
 - 3) The same is true of the infrastructure (roads, bridges, etc).
- 5. From December 1811 through February 1812, the New Madrid Fault experienced three earthquakes, each of which was over a magnitude 8 on the Richter scale. These quakes were accompanied by a series of aftershocks, at least 15 of which were felt as far away as Washington D.C.
 - 6. Although this series of earthquakes represents the largest ever recorded in the Continental United States, the New Madrid Fault has not received the same notoriety as the San Andreas Fault in California. There are several reasons.
 - a. First, because of the primitive communications system of the early 19th Century, it took days for the Atlantic States to learn that the shocks felt on the East Coast had originated in the Mississippi Valley.
 - b. Also, the newsworthiness of this information was diminished both by slow communication and by events that were leading up to the War of 1812.
 - c. Another significant factor is the Mississippi Valley was sparsely populated at the time the 1811 – 1812 earthquakes occurred.
 - 7. Today the potential for major disaster is much greater.
 - a. Cities have sprung up throughout the Mississippi Valley since that time. Today over 12.5 million people live in the region affected by the 1811 – 1812 events. Similar relative population increases have occurred throughout the state.

- b. Earth scientists estimate that enough energy has built up in the New Madrid Zone to produce an earthquake of 7.5 on the Richter scale. This is a comparable magnitude to the 1999 Izmit, Turkey earthquake and the 2001 Bhuj, Turkey earthquake. Such a quake could be felt by half of the population of the United States and by everyone in Kentucky. The Purchase Area of Western Kentucky could be severely damaged. In Louisville, Lexington and Frankfort the ground would shake very strongly resulting in walls cracking and plaster falling throughout this region.

B. ASSUMPTIONS

1. Primary Assumptions

- a. The Commonwealth of Kentucky is vulnerable to a significant threat of damage from earthquakes in the New Madrid Fault Region that could affect the entire state.
- b. Earthquakes may occur in areas where faults have not yet been identified, as with the 1980 Sharpsburg event, and could result in damage to property and injuries to people. Typical damage could be buildings destroyed, infrastructure disrupted, and landslides on steep slopes.

2. Specific Assumptions

a. Medical

- 1) A major earthquake would create extraordinary requirements for emergency medical services.
- 2) Injuries serious enough to require hospitalization are estimated to be about four times greater than fatalities.
- 3) Health care may be seriously impaired by damage, limiting the number of hospital beds and medical supplies that are available immediately following an earthquake.
- 4) The number of health care professionals available may also be limited in the event of an earthquake because some professionals may be isolated from their work places, as well as among the dead and injured.
- 5) Existing emergency medical services may be unable to respond in a meaningful manner. In this event, the National Disaster Medical System (NDMS) may be called upon to assist in relief efforts, see Appendix M-2 (National Disaster Medical System).
- 6) The number of fatalities may overwhelm the local mortuary services and the county coroner. Federal assistance may be needed.

7) Additional information can be found in Annex M (Health and Medical).

b. Economic

- 1) Business and industry may not be prepared for adequate response to an earthquake. Businesses that rely on computer-based systems are particularly vulnerable.
- 2) Failure of banking systems, which use electronic fund transfers, could result in widespread economic problems.
- 3) A damaging earthquake may cause a serious loss of employment, which could impact economic factors at the local, state, and national levels.

c. Relief Efforts

- 1) Following an earthquake, the affected area may be isolated from surrounding areas. Therefore, planning and coordination among communities in the affected area is essential for effective emergency response.
- 2) In the event rubble and debris resulting from an earthquake prevent access to the affected area for a prolonged time, helicopters may be necessary to bring rescue teams in and remove casualties from the area.
- 3) Food supply lines could break down.
- 4) The first few hours following an earthquake are critical in saving the lives of people trapped in collapsed buildings. Therefore, the use of local resources during the initial response period will be essential until state and federal support is available.
- 5) It may be several hours before personnel and equipment can be mobilized and initial teams deployed to affected areas. Therefore, state and local resources will be relied upon heavily in the period immediately following the earthquake.

d. Secondary Effects

- 1) The earthquakes and aftershocks may trigger one or more secondary events such as landslides, release of hazardous materials, dam failure or flooding.
- 2) Fires, burning out of control, involving major portions of a city are possible in the business sections because of the nature and density of construction in the affected areas. Large, uncontrolled fires are less

likely in residential areas because the housing density is less than in the business sections. However, there may be some individual or small group fires that occur as the result of miscellaneous damage related factors or weather conditions.

- 3) Should high water conditions exist during the time an earthquake occurs levees may be sufficiently damaged to allow flooding to occur behind them, especially in low lying areas.
- 4) Earthen dams are not expected to be damaged to the extent they will lose their reservoirs.
- 5) Hazardous material releases ranging from minor environmental impact to major environmental impact may occur.

e. Structural Damage

- 1) One or more dams may fail. An inventory of Kentucky dams maintained by the U.S. Army Corps of Engineers and the Kentucky Cabinet for Natural Resources and Environmental Protection, Division of Water listed 210 dams as “high hazard”, 75 as “unsafe”, and five as “urgent”. Counties should contact the U.S. Army Corps of Engineers and the Kentucky Cabinet for Natural Resources and Environmental Protection, Division of Water to determine status of dams.
- 2) Deaths and injuries are expected to be principally the result of the failure of man made structures, particularly older, multi-story and non-reinforced brick masonry buildings built before the adoption of earthquake resistant building codes.

f. Utilities

- 1) In the civil sector there may be minimal communications for a considerable length of time.
- 2) Many gas lines that travel from the South to the Northeast cut through Kentucky. These are vulnerable to rupture and leading to an explosion and fire.
- 3) A number of crude oil pipelines are in operation in Kentucky. A break in one of these lines could cause significant environmental damage and could impact on portable water service.
- 4) Commercial telephone service is vulnerable, particularly due to the possible rupture of underground cables that cross faults. Should the commercial telephone system fail, the Amateur Radio Emergency System (ARES) may be implemented to support relief efforts.

- 5) Also affected will be cellular telephone service. The towers that relay signals to and from satellites may be jarred out of adjustment.
- 6) Electrical power systems are among the most fragile in the event of an earthquake. Because they are also among the most essential of the utilities, even a short-term loss can be a major setback to a community. The loss of electric power during an earthquake may mean no water to fight fires or for drinking water, no light or heat, no communications, no sewage pumps, etc.
- 7) Water and sewage systems are vulnerable to ground movement. Disruption of the water system can lead to loss of portable water and a loss of water for firefighting. Disruption of the sewage system can result in environmental damage and increased health risks.

g. Transportation

- 1) Damage to transportation systems may severely hamper recovery efforts following an earthquake. The loss or impairment of major rail and highway links serving the city may significantly increase the difficulty of rescue and relief efforts, and may also have long term disrupting effect upon regional and national commerce.
- 2) Riverport cities built on alluvial soil may sustain substantial damage to their infrastructure that limits the usefulness of the facilities in relief efforts.
- 3) Partial or limited availability of airport facilities is expected following an earthquake. Facilities that rely on electrical power, i.e. navigation aids and runway lighting, may be out of commission for some period of time, even if emergency power is available. Runways may be available at least for limited use, even in severely affected areas.

- h. Debris removal may be a major problem, see Annex V (Recovery) for debris removal procedures.

II. MISSION

To establish basic policies for direction and control of emergency operations in response to an earthquake.

III. DIRECTION AND CONTROL

Direction and Control for earthquake operations is exercised by the Governor, through his designated representative. Federal resources, which supplement state efforts, will be directed by the state in coordination with the federal government agency that supplies them. Direction and control will be consistent with guidance

found in Annex A, Direction and Control.

IV. CONCEPT OF OPERATIONS

- A. Emergency responsibilities assigned to local agencies for earthquake response parallel those for other disaster operations.
- B. When an earthquake occurs, local authorities within damaged areas will use available resources to protect life and property, and reduce to the extent possible the suffering and hardships on individual. If local resources prove to be inadequate, or are exhausted, assistance will be requested from other jurisdictions through mutual aid procedures.
 - 1. These procedures need to be in place before the incident to insure legal and financial conditions are delineated. Jurisdictions in the areas sustaining little or no damage will be called upon to support the affected areas.
 - 2. When requirements are beyond the capability of local government, requests for assistance will be forwarded to KyEM in accordance with this plan.
 - 3. When resource requirements cannot be met with state resources, KyEM will request federal assistance in accordance with applicable federal laws, policies, procedures and plans. Federal response will be coordinated under the National Response Plan.
- C. Emergency operations will begin with the occurrence of a damaging earthquake and continue until emergency operations are no longer required. Operational procedures for response to an earthquake are discussed in the functional annexes of this EOP. For example, information relating to treatment of injuries sustained in an earthquake is addressed in Annex M (Health and Medical). Other functional areas are treated in a similar fashion.
- D. Operations and missions required as a result of an earthquake will be carried out during given phases of emergency management: Preparedness, Response, and Recovery.
 - 1. Preparedness Phase

The Preparedness Phase occurs prior to and in anticipation of a catastrophic earthquake. This phase focuses on promotion of increased public awareness of the potential emergency, preparation of necessary materials and equipment for response to the emergency, and training for emergency response personnel. Typical functions of the Preparedness Phase include conducting public information programs, maintaining emergency resource inventory lists and conducting exercise and training programs.
 - 2. Response Phase

The Response Phase occurs from the onset of the earthquake and lasts until lifeline systems are at least partially restored. It includes the period of aftershocks. During this phase, functions that are critical to saving lives, protecting people and meeting basic human needs are performed.

3. Recovery Phase

The Recovery Phase usually overlaps the Response Phase. It begins a few days after the earthquake and can last as long as two years. During the Recovery Phase, the federal government provides disaster relief upon Presidential Declaration. Functions during this phase include federal relief under P.L. 93.288, as amended, for public and individual assistance, establishment of Disaster Assistance Centers, establishment of temporary housing facilities, and federal disaster loans and grants. Long-term recovery includes restoration of affected areas to their normal or to a substantially improved state. See Annex V, Recovery.

V. ADMINISTRATIVE SUPPORT

Each agency will develop an internal staff and procedures for administrative support.

VI. APPENDICES

DD-1 Modified Mercalli Intensity Scale of 1931

DD-2 Richter Scale

DD-3 Major Fault Systems in Kentucky

DD-4 Earthquakes in Kentucky (1974-2000)

APPENDIX DD-1
MODIFIED MERCALLI INTENSITY SCALE OF 1931

LEVEL	DESCRIPTION
I	<p>Not felt except by a very few under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt:</p> <ul style="list-style-type: none"> • sometimes birds and animals reported uneasy or disturbed; • sometimes dizziness or nausea experienced; • sometimes trees, structures, liquids, bodies of water may sway; • doors may swing, very slowly.
II	<p>Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons. Also, as in Level I, but often more noticeably:</p> <ul style="list-style-type: none"> • sometimes hanging objects may swing, especially when delicately suspended; • sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly; • sometimes birds and animals reported uneasy and disturbed; • sometimes dizziness or nausea experienced.
III	<p>Felt indoors by several, motion usually rapid vibration. Other observations include:</p> <ul style="list-style-type: none"> • sometimes not recognized to be an earthquake at first; • duration estimated in some cases; • vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away; • hanging objects may swing slightly; • movements may be appreciable on upper levels of tall structures; • standing motorcars may rock slightly.
IV	<p>Felt indoors by many, outdoors by few. Other observations include:</p> <ul style="list-style-type: none"> • awakened few, especially light sleepers; • frightened no one, unless apprehensive from previous experience; • vibration like that due to passing heavy or heavily loaded trucks; • sensation like heavy body striking building or falling of heavy objects inside; • rattling of dishes, windows, doors; glassware and crockery clink or clash; • creaking of walls, frame, especially in the upper range of this level; • hanging objects swung, in numerous instances; • liquids in open vessels disturbed slightly; • standing motorcars rocked noticeably.
V	<p>Felt indoors by practically all, outdoors by many or most; outdoors direction estimated. Other observations include:</p> <ul style="list-style-type: none"> • awakened many or most; • frightened few – slight excitement, a few ran outdoors; • buildings trembled throughout event; • broken dishes and glassware to some extent; • cracked windows – in some cases, but not generally or considerably; • knocked pictures against walls or swung them out of place; • doors and shutters opened, or closed abruptly; • pendulum clocks stopped, started or ran fast, or slow; • moved small objects, furnishings, and the latter to slight extent; • spilled liquids in small amounts from well-filled open containers; • trees and bushes shaken slightly.

<p>VI</p>	<p>Felt by all, indoors and outdoors. Other observations include:</p> <ul style="list-style-type: none"> • awakened all; • frightened many, excitement general, some alarm, many ran outdoors; • persons made to move unsteadily; • trees and bushes shaken slightly to moderately; • liquid set in strong motion; • small bells rang – church, chapel, school, etc; • damage slight in poorly built buildings; • fall of plaster in small amount; cracked plaster somewhat, especially fine cracks in chimneys in some instances; • broken dishes, glassware, in considerable quantity, also some windows; • knickknacks, books and pictures fall; • overturned furniture in many instances; moved furniture of moderately heavy kind.
<p>VII</p>	<p>Frightened all – general alarm, all ran outdoors. Other observations include:</p> <ul style="list-style-type: none"> • some or many found it difficult to stand; • noticed by persons driving motorcars; • trees and bushes shaken moderately to strongly; • waves on ponds, lakes and running water; • water turbid from mud stirred up; • incaving to some extent of sand and gravel stream banks; • large church bells rang; • suspended objects made to quiver; • damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc; • cracked chimneys to considerable extent, walls to some extent; • fall of plaster in considerable to large amount, also some stucco; • numerous broken windows and furniture to some extent; • shook down loosened brickwork and tiles; • cornices falling from towers and high buildings; • dislodged bricks and stones; • overturned heavy furniture, with damage from breaking; • damage considerable to concrete irrigation ditches.
<p>VIII</p>	<p>Fright general – alarm approaches panic. Other observations include:</p> <ul style="list-style-type: none"> • persons driving motorcars disturbed; • trees shaken strongly – branches and trunks broken off, especially palm trees; • ejected sand and mud in small amounts; • temporary and permanent changes in flow of spring and well waters; • damage slight in specially built structures; considerable in ordinary substantial buildings with partial collapse, great in poorly built structures; • panel walls thrown out of frame structures; • fall of chimneys, factory stacks, columns, monuments and walls; • moved and overturned very heavy furniture; • sand and mud ejected in small amounts; • changes in well water.

IX	<p>Panic general. Other observations include:</p> <ul style="list-style-type: none"> • ground cracked conspicuously; • damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse; • buildings shifted off foundations; racked frames; serious damage to reservoirs; underground pipes sometimes broken;
X	<p>Ground cracks, especially when loose and wet, widths up to several inches; fishers up to a yard in width run parallel to canal and stream banks. Other observations include:</p> <ul style="list-style-type: none"> • landslides considerable from riverbanks and steep coasts; • shifted sand and mud horizontally on beaches and flat land; • changed level of water in wells; • water thrown on banks of canals and lakes, rivers, etc; • damage serious to dams, dikes and embankments; • some well-built wooden structures and bridges destroyed; • dangerous cracks develop in excellent brick walls; • most masonry and frame structures and their foundations are destroyed; • railroad rails are bent slightly; • pipelines buried in earth are torn apart or crushed endwise; • open cracks and broad wavy folds in cement pavements and asphalt road surfaces.
XI	<p>Ground disturbances are many and widespread, varying with ground material. Other observations include:</p> <ul style="list-style-type: none"> • broad fissures, earth slumps, and land slides in soft wet ground; • ejected water in large amounts charges with sand and mud; • caused sea-waves ("tidal" waves) of significant magnitude; • damage severe to wood-frame structures, especially near shock centers; • great damage to dams, dikes and embankments often for long distances; • few, if any, (masonry) structures remain standing; • large well-built bridges destroyed by the wreaking of supporting piers or pillars; • yielding wooden bridges affected less; • railroad rails bent greatly and thrust endwise; • underground pipelines completely out of service.
XII	<p>Damage total – practically all works of construction are damaged greatly or destroyed. Other observations include:</p> <ul style="list-style-type: none"> • disturbances in ground are great and varied with numerous shearing cracks; • landslides and falls of rock are of significant character, slumping of riverbanks are numerous and extensive; • large rock masses are wrenched loose and tore off; • fault slips in firm rock, with notable horizontal and vertical offset displacements; • surface and underground water channels are disturbed and modified greatly; • dammed lakes produce waterfalls and rivers are deflected; • waves seen on ground surface, in some cases; • lines of site and level are distorted; • objects are thrown into the air.

APPENDIX DD-2 RICHTER SCALE

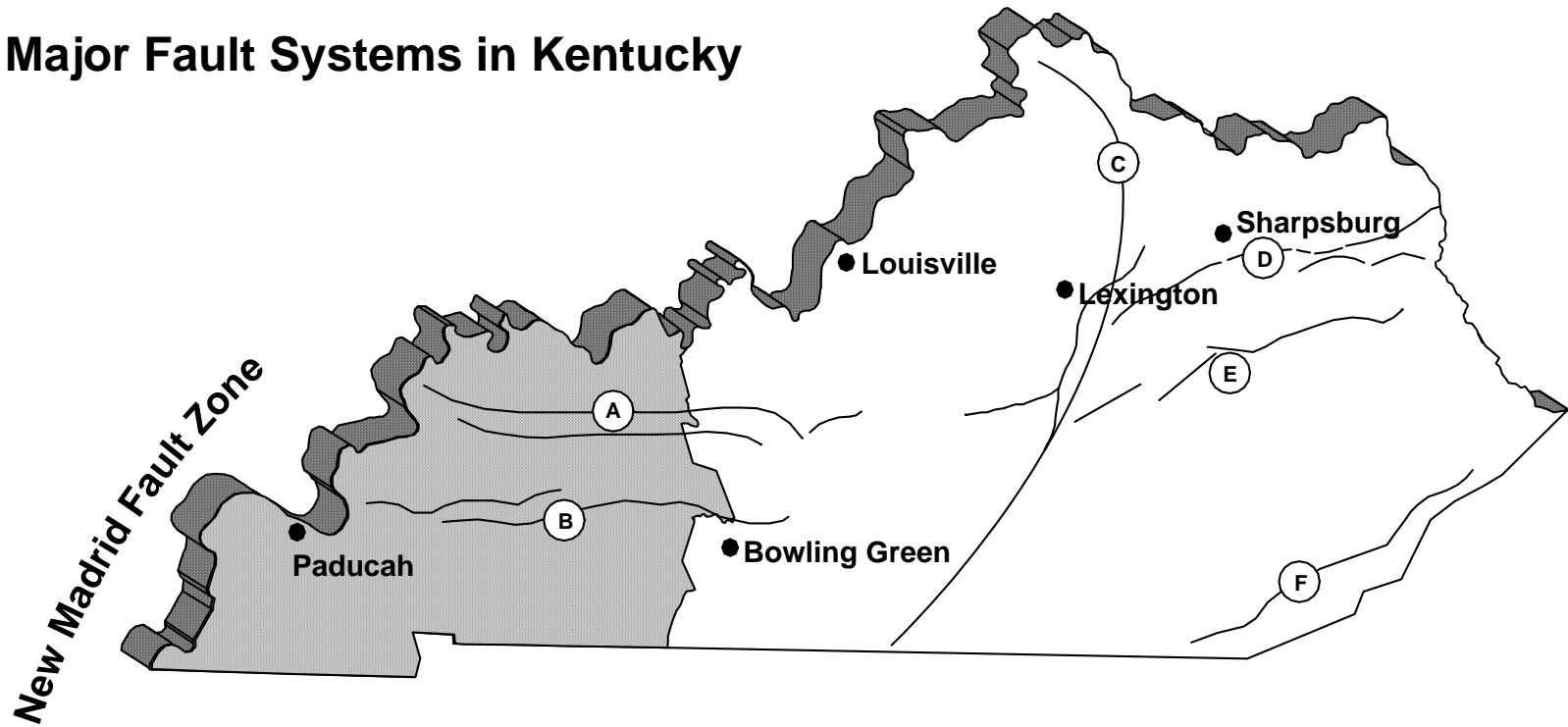
RICHTER SCALE

The Richter Scale can be defined as a measurement whereby the amplitude of an earthquake is depicted on a logarithmic scale in which each higher level of released energy or magnitude, represents an increase of about thirty-fold in strength. An example of this is that an earthquake of 8.0 magnitude does not release twice the energy as one of 4.0 magnitude, but rather releases 30x 30x 30x 30 times.

A general correlation between the Richter magnitude scale and probable effects or intensity are:

<u>Magnitude</u>	<u>Intensity</u>
1	Detectable only by instruments.
2.0 – 2.9	Barely perceptible, even near epicenter.
3.0 – 3.9	Felt by most people if nearby.
4.0 – 4.9	Minor shock, damage slight and localized.
5.0 – 5.9	Moderate shock, energy released equivalent to atomic bomb.
6.0 – 6.9	Large shock, can be destructive in populated area.
7.0 – 7.9	Major earthquake. Inflicts serious damage. Recorded over the entire world.
8.0 – 8.9	Massive earthquake. Produces total destruction to nearby communities. Energy released is millions of times that released by first atomic bomb.
9.0 – >	Largest earthquake. Maximum energy earth is thought to be capable of storing.

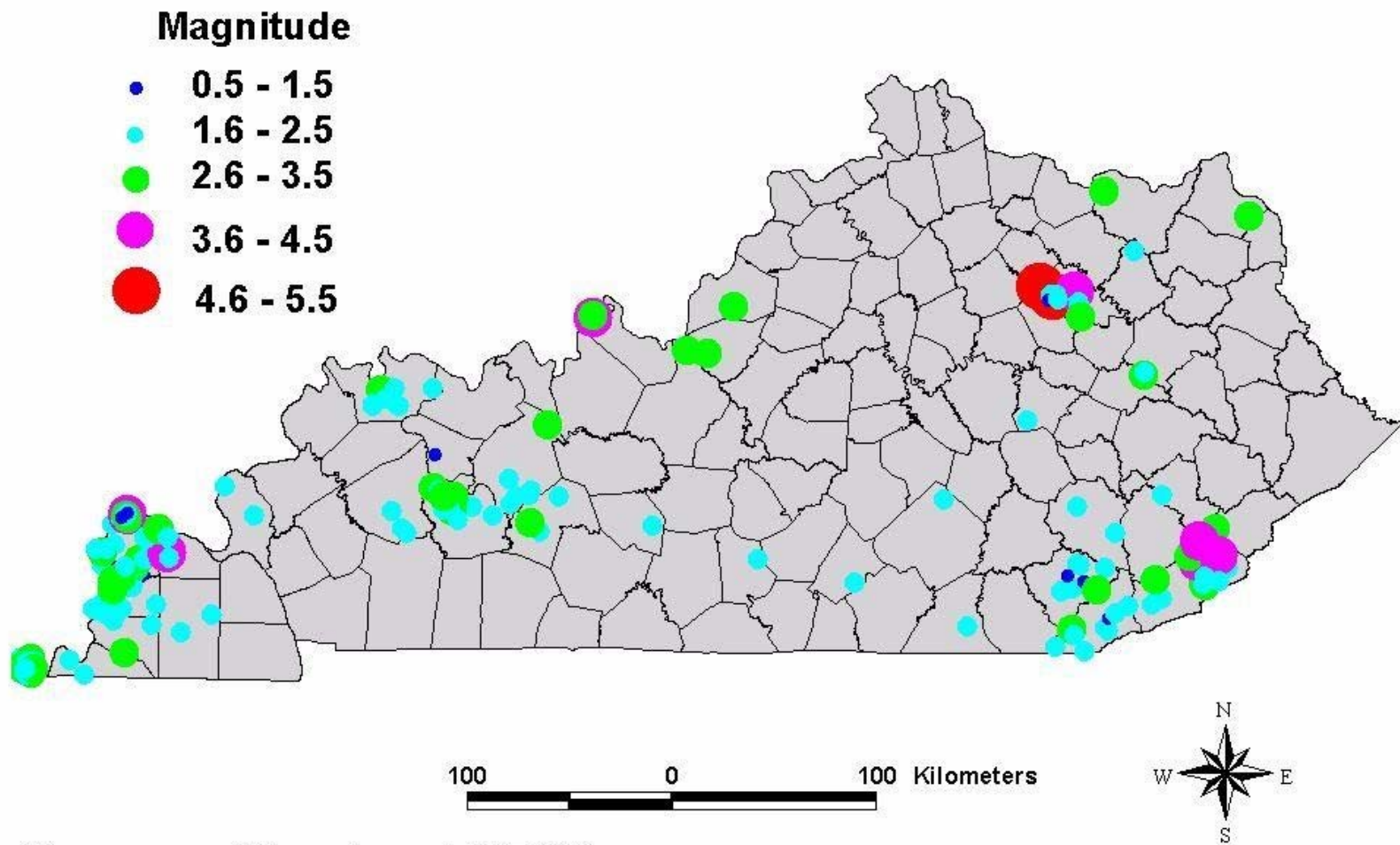
Major Fault Systems in Kentucky



Shaded area denotes approximate Mercalli Zone IX extents.

LEGEND	
A Rough Creek Fault System	D Kentucky River Fault System
B Pennyryle Fault System	E Irvine-Paint Creek Fault System
C Cincinnati Arch	F Pine Mountain Thrust Fault

Earthquakes In Kentucky (1974-2000)



(Sources: Street and CERI)

APPENDIX DD-4
EARTHQUAKES IN KENTUCKY (1974-2000)